

LA-UR-21-21291

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Title: Orbital ring and Dyson sphere from recycled space debris

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Intended for: Web

Issued: 2021-02-11

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Orbital ring and Dyson sphere from recycled space debris

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(Feb. 4, 2021)

Abstract: *Existing materials are sufficiently strong for space elevators which anchor at an orbital ring or a Dyson sphere in the Low Earth Orbits (LEO). Based on recycled space debris, an orbital ring or a Dyson sphere also brings benefits to the climate and energy shortage problems, in addition to the primary purpose of colonization of space and other planets in the solar system.*

The space debris problem and high cost of rocket payloads are two well-known problems in the ambitious march towards turning the human and other Earthly residents including animals and plants into multi-planetary species. Most of the proposed debris removal techniques aim at de-orbiting the LEO and higher altitude dysfunctional objects and plunge them back to the Earth. Low cost access to space by both human and materials are also essential to massive relocation of humans and materials to LEO and other planets.

We describe a concept to address two important problems at once: the space debris problem and the high cost of rocket payloads. The idea is to recycle the space debris for functional ring structure or Dyson sphere construction in LEO, as illustrated by Figure 1. Space debris is a widely recognized urgent problem that, if left unaddressed, could cripple the rapidly expanding space activities in the coming decades. More than 500,000 pieces of sufficiently large pieces of debris are currently tracked due to their potential threat to space assets and human space activities. Space debris at LEO travels at speeds around 7.8 km/s. A one-centimeter debris could strike a satellite or a spacecraft with an equivalent force of an exploding hand grenade, causing irreversible damage to expensive equipment and spacecrafts. NASA, ESA and others have designed various Earth and space-based methods for space debris removal. ESA's active debris removal demonstration mission is called e-Deorbit, which involves launching satellites to capture and deorbit the space debris and return them back to the Earth. Additional spacecraft life-extension through refuel and repair are also being considered in conjunction with e-Deorbit missions recently. The second problem, the high cost of rocket payloads, is the bottleneck for many space-oriented activities such as Moon or Mars colonization, and other mega space projects such as solar-energy farms in the space.

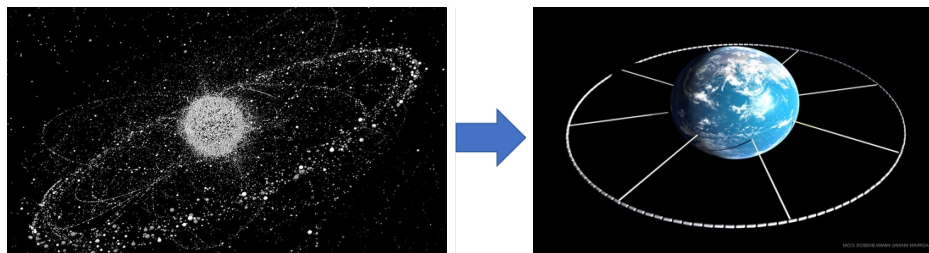


Figure 1. A concept that turns space debris into functional Earth orbital rings and Dyson spheres. (Left). Visualization of space debris distribution as of 2018. It is estimated that the total number of space debris objects in orbit is around 29 000 for sizes larger than 10 cm, 670 000 larger than 1 cm, and more than 170

million larger than 1 mm. (Right). An artistic depiction of an orbital ring with multiple space elevators (spokes) connecting the orbit ring to the Earth's surface. Only a 2D concept is shown here. There is no fundamental reason preventing the construction of a 3D structure, such as a Dyson sphere at LEO.

In a series of papers published in the 1980's [1], Paul Birch established a mathematical framework for orbital ring systems, as well as the potential usages of orbital ring as the anchor of space elevators for material and human transport between the Earth's surface and low Earth orbits. One or more space elevators can anchor at the orbital ring, as illustrated in Fig.1. These space elevators could lower the cost per kilogram to place payloads in orbit to below \$100/kg, a factor of 100 or more reduction from the current rate (reuse of the rockets have been gradually reducing this cost). In contrast to a space elevator that would anchor at the Earth's geosynchronous orbit, which would require futuristic materials based on carbon nanotubes and has been investigated in depth previously at LANL [2], the new space elevator anchored at LEO to orbital rings or Dyson spheres could use *existing high tensile* strength materials as estimated in Figure 2.

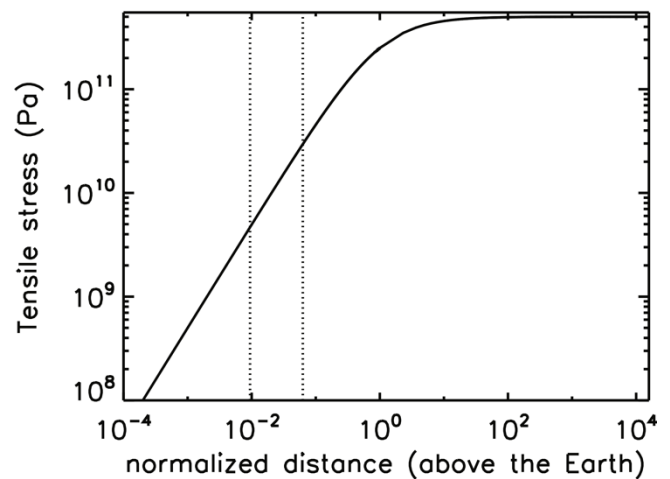


Figure 2. An orbital ring in a low altitude of 60 to 600 km above the Earth (bounded by two vertical dashed lines, normalized to the Earth radius) reduces the tensile stress exponentially for space elevator structures from a ring at the Earth's geosynchronous orbit.

Another possible use of an orbital ring or a Dyson sphere is to relay the solar power from the space back to the Earth, the carbon-free and inexhaustible solar energy transported from space back to the Earth can address the climate change, energy supply and other issues facing the growing population. The concept further opens door to space science missions and will advance our understanding of the space environment from the Sun to the Earth and beyond. The space debris recycling, prototype orbital ring/Dyson sphere construction, orbital ring stabilization, space elevator designs will call upon contributions from broad scientific and technological communities. Further conceptual studies will also be needed to address engineering of orbital ring and Dyson sphere designs and stabilities. Initial space debris recycling schemes could be addressed through novel uses of CubeSat for conceptual and prototype structure demonstrations. The design of orbital rings such as altitude and inclination may leverage existing modeling and satellite mission design capabilities.

References:

- [1] Paul Birch, *Journal of the British Interplanetary Society* **35** (1982) 475; **36** (1982) 115; **36** (1982) 231;
- [2] B. C. Edwards, *Acta Astronautica* **47** (2000) 735.